Chapter

The Colombian Banking Sector: Analysis from Relative Efficiency

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Abstract

The banking sector is that sector of the modern economy that is primarily called upon to play the important role of intermediation between the surplus agents and the deficit agents. Based on this fact, this research presents and analyzes the behavior of banks in Colombia since 2002 and up to 2016 (15 years) through the application of data envelopment analysis, a nonparametric methodology of advanced linear programming, which generates a single efficiency indicator for each unit studied in each period, optimizing multiple resources (inputs) and multiple products (outputs). One aspect of the results shows that for the year 2014, 71% of the banks were efficient, this being the highest result within the period studied.

Keywords: Colombian banking sector, banking efficiency, data envelopment analysis, efficiency measurement, relative efficiency

1. Introduction

In the development of any economy, the banking sector plays a key role, since it is primarily that sector that advances the task of intermediation between the so-called surplus agents (they do not spend the total of their monetary resources, the savers) and the so-called deficit agents (require additional monetary resources); this is one of the reasons why banks exist in all countries. Additionally, because they transmit to the population in general, monetary and credit policies issued by central banks and/or governments in such a way that they become one of the key sectors in every economy since an important part of savings, investment and financing goes through their intermediation. Otherwise, banks play a preponderant role in determining living standards within modern economies, so much so that [1] banks have the ability to stimulate and collect the savings of a society and distribute them among companies and sectors that need capital as an input for their economic activities.

Banks are important within any financial system; for example, in the United States in mid-2017, there were 7,836 member banks of the Federal Deposit Insurance Corporation. According to [2], within the European Union as of November 2016, there were 127 larger banking groups and according to [3], in Latin America, there are 23 banks in Chile; according to [4], in Mexico, there were 47 institutions of multiple banking as of December 2016 and in Colombia 25 banks as of December 2016.

According to [5], within the Colombian financial system, banks are part of the credit facilities supervised by the Superintendencia Financiera de Colombia (SFC), along with financial corporations, traditional financing companies, leasing specialized finance companies, and financial cooperatives. According to [6], the credit institutions are financial institutions whose main function is to capture

legal currency resources from the public, either in sight deposits (savings accounts and current accounts) or in term deposits (CDT and CDAT'S), to place them again through loans, discounts, advances, or other active credit operations. According to [7], being watched by the SFC means that there is an institution that authorizes and monitors the activity carried out by entities that receive monies from the public, where you save, invest your capital, and have a loan, insurance, or your pension. According to Decree 663 of April 2, 1993, published in the Official Gazette No. 40, 820, Organic Statute of the Financial System [8], in its Article 2 it is made explicit that the main function of banking establishments is the capture of resources in bank current account, as well as the collection of other sight or term deposits, with the primary objective of making active credit operations.

Given the importance of the banking sector worldwide, this research analyzes the behavior of the Colombian banking sector during the last 15 years, using the nonparametric methodology data envelopment analysis (DEA) to generate relative efficiency indicators for each of the banks and for every year throughout the study period; questions are answered: are there efficient banks throughout the period? What are the average efficiency levels of the sector for each year? In what year or years were there better results of relative efficiency?

2. Colombian banking sector

In 1923 and through Law 25, the Banco de la República was created, the second central bank created in the region, a year before that had been created in Peru. According to [9], between the years 1922 and 1950, 17 central banks were created in the region under the guidance of Edwin Walter Kemmerer. Along with the approval of Law 25 of 1923, which established the organic status of the Banco de la República, Law 45 was approved, which regulated private banks and established the Banking Superintendency, seeking to allow the stable functioning of the Colombian financial sector [10]. In the nineties, the transition to a universal banking system began, with an emphasis on commercial banks. In [11], a scheme of subsidiaries and matrices was standardized, the structure of the sector and its services was redefined, and the entry and exit of markets were liberalized.

The financial crises of the twentieth century resulted in the closure of entities and processes of internal mergers and acquisitions, which consolidated the system in the early twenty-first century transforming the financial sector. According to [12], the period from 2002 to 2009 was characterized by an environment of economic recovery, by the high flows of foreign capital and by the increase in the services provided by the banks. During these years, the transformations led to a reduction in the number of financial institutions, which went from more than forty banks between mortgages and commercials, in the mid-1990s, to less than twenty in 2009. The same is true for [13], those between 1995 and 2009, the financial sector had a consolidation process.

In such a way that the competition for the market resumed, always with two big banks at the head, Bancolombia and Grupo Aval. But Banco Davivienda bought Bancafé and it became the third bank; Granahorrar was bought by BBVA, positioning itself as the fourth bank in the country. For the year 2008, 72% of the Colombian banking market was distributed as follows, in importance: Aval, Bancolombia, Davivienda, and BBVA.

For the last few years, and in global terms, it is observed that the Colombian financial sector is monopolized by a few financial groups, which through their business conglomerates offer an extensive portfolio of banking services, securities administration, insurance, investment fund management, layoffs, and pensions, among others. According to [14], for 2014, only 10 of the 33 most representative

companies in the sector accounted for 68% of total investments: Bancolombia, Porvenir, Banco de Bogotá, Davivienda, Protección, BBVA, Banco de Occidente, Corpbanca, Banco Agrario, and Colpatria; of these 10, eight are banks. Regarding income, 61% of the total was concentrated in ten entities: 7 banks, 2 insurers, and one administrator of pension and severance funds: Bancolombia, Banco Agrario, Banco de Bogotá, Banco de Occidente, Davivienda, Protección, BBVA and Banco Corpbanca, insurer Suramericana, insurer Positiva, and Porvenir administrator. In relation to profits only 8 concentrated 66% of the total profits of the sector; among these are Bancolombia, Banco Agrario, Banco de Bogota, Banco de Occidente, Davivienda, Banco Colpatria, Banco Popular, and Suramericana Vida.

For the year 2016, in Colombia, there are four important national financial groups with international operations: Grupo Aval, Grupo Bancolombia, Grupo Bolívar, and Grupo Colpatria.

According to [15], the Aval Group is one of the most important financial groups in Colombia; even on its website, it calls itself "Colombia's largest financial group". Specifically, it is the largest financial conglomerate in Colombia and through of BAC Credomatic is the largest and most profitable regional group in Central America. It has four banks: Banco de Bogotá, Banco de Occidente, Banco Popular, and Banco AV Villas. Banco de Bogotá: it is the financial institution with the longest history in the country (founded in 1870), the second largest bank in Colombia by size of assets, and the largest company in the Aval Group due to its level of assets, deposits, and profits. Banco de Occidente: it is the fifth largest bank in Colombia by asset level and portfolio and the third largest bank in current accounts. Banco Popular: is a pioneer in the promissory note market and provides financial solutions for government entities in Colombia. AV Villas Bank: it has gone from being exclusively focused on housing loans, to be a consumer-oriented universal bank; it is the group's most active bank, in the use of nontraditional channels: mobile banking, nonbank correspondents, and virtual branches.

Another of the important groups is the Grupo Bancolombia, which denotes that 142 years have passed since its birth [16]; this group originated from the merger of the Bank of Colombia and the Industrial Colombiano Bank, later merged with Conavi (2005) and Confisura. Bancolombia is the largest private bank in the country due to the size of its equity and assets [17].

The Grupo Empresarial Bolívar is a conglomerate of companies that are coordinated and controlled through Sociedades Bolívar. Banco Davivienda belongs to this group, which originated in the Colombian Savings and Housing Corporation, Coldeahorro (founded in 1972) and the Superior Banks (merger in 2005) and Granbanco-Bancafe [18]. In mid-2017 and according to the information on its website [19], it is consistently positioned among the first three banks in the country, with a record number of customers for 2016 of 7,714,552 and 593 offices.

The Grupo Colpatria—Red Multibanca has a banking unit (bank and fiduciary), a construction unit, an investment unit, and Colfondos. In October 2011, Colpatria, the group's holding, announced the Bank's new partner: the multinational Scotiabank, with whom they signed a long-term strategic alliance; this multinational institution is one of the main financial institutions in North America and Canada [20].

The international financial groups with presence in Colombia are: BBVA, Citibank, GNB Sudameris, and Corpbanca.

Grupo BBVA: is composed of a Spanish banking entity with over a century and a half of experience, which after mergers and acquisitions both nationally and internationally, is currently the Grupo BBVA. According to [21], in 1996, it made a presence in Colombia through the purchase of 40% of Banco Ganadero; in 2004, it was renamed BBVA Colombia, and in 2006, it merged with Banco Granahorrar.

Grupo Citibank: the history of Citibank in the world began in the United States in 1812, when the City Bank of New York (today Citibank) was founded [22]. Citibank Colombia is a Citigroup franchise. The group is composed of the controlling company, Citibank Colombia S.A. and the subordinates [23]. According to [24], Citi in Colombia opened the first branch in 1916; since 1986, it has organized according to the model of Consumer Banking and Corporate Banking.

Grupo GNB Sudameris: in 1920, the bank was born as a Colombian mercantile company; after acquisitions and sales in 2004 Banco Sudameris acquires the majority shareholding of Banco Tequendama and Servibanca. At the beginning of 2014, the incorporation of the HSBC operation was formalized. The group currently consists of the Banco GNB Sudameris and 7 companies [25].

Grupo Corpbanca: Banco CorpBanca was created in 1997 from the merger of Banco Concepción Chileno and Banco Corp Group. Since then, it has positioned itself in the Chilean market as the fourth most important bank. For [26], in 2012 arrived at the Colombian market. Currently, Banco Corpbanca Colombia has four subsidiary companies.

Otherwise, at the December 2016 cutoff and using the SFC as an information source, it can be seen that within the Colombian financial system, there are 25 banks that represent 11% of the total of the entities in the sector, but in terms of participation in assets, banks represent 93%. For example, savings and housing cooperatives have a 78% stake in the entities, but only 2.1% participation in the sector's assets. Within the aforementioned 25 banks, there are 14 national (including the two cooperatives owned), 10 foreign, and one public.

According to [27], the banking sector closed in 2016 with total assets of $ 548 billion, an increase of 8.6% over the previous year and 126% in relation to the result for 2010, with an increasing trend in this period; the entities with the greatest assets at the end of 2016 are the Bancolombia, the Banco de Bogotá and Davivienda.

With respect to the gross portfolio, 2016 closed with $ 394 billion, representing an increase of 12% with respect to 2015 and 148% with respect to 2010, with an ever-increasing trend. By the end of 2016, the commercial portfolio of the banking sector participates with 58%, while the consumer portfolio with 27%, housing with 13%, and microcredit with only 3%; these shares are very similar to those of the immediately previous year.

Looking at the behavior of the liability, it is established that at the end of 2016, it is 475 billion with a growth of 9% for this last year, and between the years 2010 and 2016 with a growth of 125% with an ever-increasing trend. The ratio between the granted portfolio and the deposits of the public (savings, CDT, and current accounts) for the sector is 0.92, which represents that the sector for each peso that captures places only 0.92 pesos.

3. Methodology

3.1 Data envelopment analysis (DEA)

It is a nonparametric methodology of advanced linear programming, in which a double process of optimization is carried out, establishing the relative efficiency of Decision Making Unit—DMU, for [28] specify that this is done by generating an efficient frontier that locates the individual relative indices without having prior knowledge of the production function. More specifically, according to [29], DEA is used to evaluate the relative efficiency of a set of n DMUs, by posing linear programming problems for each unit according to the data of resource utilization or inputs and product or output generation. More broadly, according to [30], the

efficiency of each DMU is defined as the relationship between weighted outputs and weighted inputs, so that it is obtained by solving a double problem of linear programming in order to determine the optimum set of weights that maximizes.

DEA has experienced a dynamic development, for [31] it gradually becoming a set of concepts and methodologies, which have materialized in a series of models. The first DEA model to be developed was the CRS (constant returns to scale) model that results in the categorical classification of each DMU [32]; after a few years, the VRS (variable returns to scale) model appears, through which not only constant returns can be worked [33], but also as [34] clarifies these returns can be incremental and decremental.

3.2 CRS model

Consider a set composed of n DMU denoted as DMU_j (j = 1, ..., n), which uses resources x_{ij} (i = 1, ..., m) and generate s outputs y_{rj} (r = 1, ..., s), part of that the multipliers v_i, u_r associated with i inputs and r outputs respectively are known. So, specifically, if the DMU_0 is under study, this model is giving the solution to the problem of fractional programming for the measure of efficiency of that DMU_0 as well [31]:

$$e_0 = \max \sum_r u_r y_{ro} / \sum_i v_i x_{io} \tag{1}$$

Subject to:

$$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0, \text{for all } j$$

$$u_r, v_i \geq \varepsilon, \text{for all } r, i$$

where ε is a nonarquimidian value designated strictly positive.

The theory of fractional programming expressed in [35] is applied and the following changes of variables are made:

$$\mu_r = t u_r y, v_i = t v_i$$

where:

$$t = \left(\sum_i v_i x_{i0}\right)^{-1}.$$

The initial problem can be transformed into the following linear programming model:

$$e_0 = \max \sum_r \mu_r y_{ro} \tag{2}$$

Subject to:

$$\sum_i v_i x_{i0} = 1$$

$$\sum_r \mu_r y_{rj} - \sum_i v_i x_{ij} \leq 0, \text{for all } j$$

$$\mu_r, v_i \geq \varepsilon, \text{for all } r, i$$

3.3 VRS model

According to [31] and all the above parameters, for this model we have a mathematical approach:

$$e_0^* = \max\left[\sum_r u_r y_{r0} - u_o\right] / \sum_i v_i x_{i0} \quad (3)$$

Subject to:

$$\sum_r u_r y_{rj} - u_o - \sum_i v_i x_{ij} \le 0 \; j = 1, \ldots, n$$

$$u_r \ge \varepsilon, v_i \ge \varepsilon, \text{for all } i, r$$

$$u_o \text{ not restricted in sign}$$

With its equivalent in linear programming:

$$e_0^* = \max \sum_r \mu_r y_{ro} - \mu_o \quad (4)$$

Subject to:

$$\sum_i v_i x_{io} = 1$$

$$\sum_r \mu_r y_{rj} - \mu_o - \sum_i v_i x_{ij} \le 0, j = 1, \ldots, n$$

$$\mu_r \ge \varepsilon, v_i \ge \varepsilon, \text{for all } i, r$$

$$\mu_o, \text{unrestricted}$$

The conventional measurement of DEA is based on the hypothesis that resources or inputs should be minimized, and products or outputs should be maximized according to [36]. Additionally, for each of these basic models, there is the orientation to the entrances and the orientation to the exits, depending on whether you want to prioritize the maximum decrease of the inputs keeping the outputs constant or the total maximization of the outputs with the constant inputs. One of the strengths of DEA is that a single efficiency result (%) is obtained for each unit, in a multi-input and multi-output context.

4. Review of current literature

The study of relative efficiency through DEA applied to banks is one of the most recurrent issues, so that some of the most recently published research is presented below. Ref. [37] measured the efficiency of the offices of a state bank in India by applying a DEA model based on slack. The diffuse DEA models are used in those

occasions in which it is considered that the accuracy of the data is not the best; for this reason, [38] used this type of model to analyze the banking sector in India.

The CRS and VRS models were used by [39] in their research to measure the efficiency of commercial banks in Slovenia, Poland, Austria, Hungary, Slovenia, and Czech Republic. These two models were also applied by [40] to study the banks of Côte d'Ivoire in West Africa, for the period 2008–2010. The VRS model was also used by [41] to study 79 bank branches in Canada, only this time they used the orientation to the inputs.

Islamic banks were studied by [42] comparing them with traditional banks using the Meta-Frontier Analysis (MFA) model. The Nash negotiation game model was combined with the centralized two-stage DEA model for [43] to study banks in China. Through an additive efficiency decomposition approach in DEA [44] evaluated the management and investment efficiencies of ICTs in Taiwan's banks for the 2007–2011 period. The Iranian banks were studied by [45] through the CRS model with output orientation. The research of [46] proposes a model with a multi-stage procedure that integrates robust methods, cluster analysis, and DEA to identify and study the efficiency of management in the different branches of the banks.

The main banks in Cambodia were studied by [47] through the DEA panel model for 13 years. [48] studied Taiwanese banks developing a new model based on DEA gaps to decompose their different components. Research from [49] focused on measuring the efficiency of marketing as a measure of performance after the merger, and this was investigated through DEA applied to 20 merger and acquisition agreements within the US commercial banking.

[50] studied the relative efficiency of 23 Colombian commercial banks for a period of 10 years, with the CRS and VRS models oriented to inputs and outputs. [51] investigated the efficiency of Colombian banking from the year 2000 until 2012; they applied the VRS model with orientation to the outputs. On the other hand, [52] compared the relative efficiency of the real sector with that of the financial sector of the Colombian economy for 2014 using the VRS model oriented to the outputs.

5. Specific methodological design

Information source: Superintendencia Financiera de Colombia.

Delimitation of the DMU: given that the Colombian banking sector is studied, the DMUs are the banks that year after year, and from 2002 and until 2016, reported their financial statements to the SFC. Reaffirming the statement by [53], DEA is generally interpreted using the notion of production technology generated by the set of observed units. For the study period, 5 government banks reported to the SFC, because they were from the government; they withdrew from the database, accepting what was expressed by [54] as to which institutions of the Government alone are comparable to each other. Additionally, a private bank that was liquidated in 1999 also reported its financial statements, but because it was not comparable, because it was not fully operational, it was also removed from the database. **Table 1** shows the number of banks that are part of the investigation for each year.

Determining the specific DEA model, as recommended by [55], since there is no evidence of constant returns to scale, we choose to use the DEA VRS model, and having a particular interest to evaluate how to obtain best results, we work with orientation to the outputs.

Delimitation of inputs and outputs: given that DEA is a nonparametric boundary model, in which it is not necessary to previously establish the production function, and that the determinant variables of the model are the resources used (inputs) and

Year	# of banks
2002	24
2003	24
2004	24
2005	19
2006	15
2007	15
2008	17
2009	17
2010	18
2011	22
2012	22
2013	23
2014	21
2015	24
2016	24

Source: self-made.

Table 1.
Number of banks that are part of the study.

Inputs	Outputs
Current assets	Operating income
Property, plant & equipment	Net income
Noncurrent liabilities	
Equity	

Source: self-made.

Table 2.
Input and output variables.

what is obtained from the process of transformation of them (outputs), the variables used in this investigation are shown in **Table 2**.

Taking into account the inputs and outputs chosen for this model and going to [56], it can be established that this model is what they call an intermediation model, which consists in measuring how the entity operates based on the monetary assets it gathers (inputs), making loans and investments (outputs).

These same input and output variables have been used by [52] and by (Rodríguez-Lozano) [57] to study the insurance brokerage companies in the Colombian financial environment through DEA indicators, and also by [58] to determine relative efficiency in two subsectors of the Colombian economy from 1993 to 2002 and [59] to determine the measurement of relative efficiency in three subsectors of the Colombian economy from 1993 to 1999.

6. Results

Table 3 shows the result of the efficient units, in percentage terms, for each year.
Table 4 shows the average efficiency levels for each year.

Year	# Units	%
2002	6	25%
2003	9	38%
2004	9	38%
2005	8	42%
2006	9	60%
2007	10	67%
2008	11	65%
2009	10	59%
2010	11	61%
2011	11	50%
2012	14	64%
2013	14	61%
2014	15	71%
2015	13	54%
2016	15	63%

Source: self-made.

Table 3.
Efficient units per year.

The study period begins with the lowest index, as previously stated is a period of recovery of the Colombian financial sector after its crisis; the highest index is in 2007, which coincides with the time before it started the first global financial crisis of this century; as of 2014 (with the second best average), the consequences of the global economic recession begin to be evident.

Year	Average efficiency (%)
2002	70
2003	79
2004	78
2005	88
2006	89
2007	95
2008	87
2009	88
2010	89
2011	90
2012	92
2013	89
2014	92
2015	86
2016	86

Source: self-made.

Table 4.
Average efficiency levels per year.

Figure 1 shows the behavior of the units, by efficiency range for the entire study period.

The results show that between the years 2002 and 2007, the percentage of efficient banks was in a clear rise, an increase of 42% points, despite the fact that the number of banks decreased; even 2007 was the year in which there were fewer banks for the 15 years studied. This confirms that since 2002, the sector experienced improvements. Additionally, in 2005, 79% of the banks were between 100 and 80% efficiency, ratifying the good results.

In 2007, the first financial crisis of the twenty-first century began and the impact of this crisis is evident from the results of 2008 and until 2011; there is a decrease of 17% points for efficient banks. At the same time, the efficiency range between 79.9 and 60 increased until reaching its maximum level in 2010 (33%). These results are consistent with those found by [60], in the sense that global financial crises impact the behavior of banks. As of 2011, a slow recovery process begins for the efficient, until 2014.

The Colombian economy ended 2015 with a rate slightly above 3%, despite the stagnation experienced in Latin America and the low global growth [61]; for the financial sector, the growth was 4.3% and according to [62], the balance of the banking sector was satisfactory. In terms of relative efficiency, it can be established that the share of the efficiency decreased at the same time as the holdings of the banks with low ranks increased. The efficient banking institutions had a fall of 17% points in a single year and for this same year the ranges 99.9–60% and lower to 40% increased their participation by 11 and 8% points, respectively. This means that more banks were unconcerned about managing their resources efficiently prioritizing other types of behavior as a process of deceleration of the beginning of world economy.

For the year 2016, in spite of continuing the deceleration of the economy, the Colombian banking sector reported good results, for example increased profits by 17% over the immediately previous year. In the same way, the participation of efficient banks improved to 63%, and the rest of the ranks were concentrated around a 10% share; leaving in this way very clear the difference of participation between the efficient banks and those that are not, a difference that began to take shape from the year 2006 and that from 2014 is stabilized by the grouping of the inefficient in participations below 20%.

6.1 Analysis by groups

Figure 2 shows the behavior in terms of relative efficiency of the 8 financial groups mentioned previously.

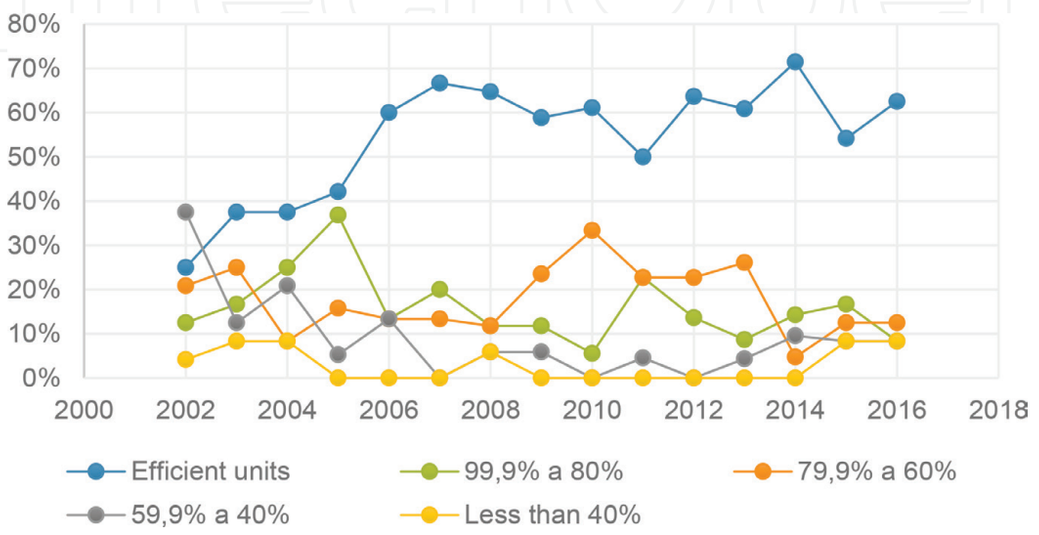

Figure 1.
Units by efficiency range. Source: self-made.

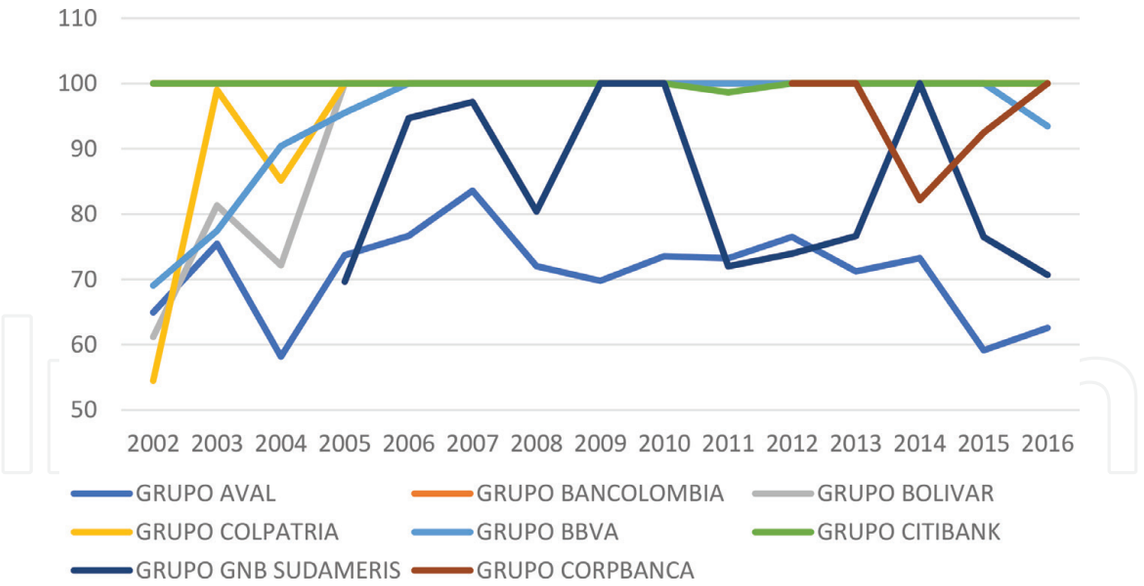

Figure 2.
Efficiency (%) of financial groups. Source: self-made.

The one that is considered the largest financial group in Colombia, Grupo Aval, is definitely the most inefficient. On the other hand, the only efficient group in all 15 years of the study is Grupo Bancolombia. Both the Grupo Bolívar (Banco Davivienda) and the Grupo Colpatria (Banco Colpatria) began the study period with relatively low rates (61 and 54% respectively) but they were improving to the point that since 2005 they are efficient and they maintained the same until 2016.

Regarding international groups, Citibank is the one with the best results, because only in 2011, it is not efficient, but its index is 99%. The behavior of the Grupo BBVA is very similar to that of the Grupo Bolívar and Grupo Colpatria, but this group is not efficient for 2016; although it is very close, its index is 93%. The Grupo Corbanca in the 5 years of presence has rates above 80% and even in 3 years it is efficient. The Grupo GNB started in 2005 with an index of 70%, improved for the next 2 years, fell, and then became efficient, and from 2011 it repeats the cycle ending in 2016 with an indicator close to 70%. The Grupo CorpBanca Group shows better results, since in three of the 5 years of presence it is efficient, and its inefficiency is not more than 20% since the indexes of those 2 years are higher than 80%.

In **Figure 3**, the behavior of the 4 banks of the Grupo AVAL is presented; there it is evident that although the one of Banco de Bogota has indexes above 80% and is efficient in 9 of the 15 years of the study, this is not enough because the remaining three banks mark downwards since they have rates that are around 60% and in the last 3 years the Banco Popular and the Banco AV Villas have very low rates.

Figure 4 shows the behavior of efficient banks according to whether they are national or not.

Foreign banks have a greater participation in 90% of the years; only for 2016, the participation of efficient national banks exceeds the participation of foreigners, although by very little.

Now, of all the banks that are part of the study, only 24% are efficient during all the years that each of them is present in the study period: Bancolombia: 15 years, Procredit: 9 years, Finandina: 6 years, Santander de Negocios: 4 years, Bankboston: 3 years, Megabaco: 4 years, Mundo Mujer: 2 years, Multibank: 2 years, and Standard Chartered: 3 years. They are not within this group because only in 1 year they were not efficient, although this indicator is above 95%: Coomeva, WWB, Bancompartir, and Citibank.

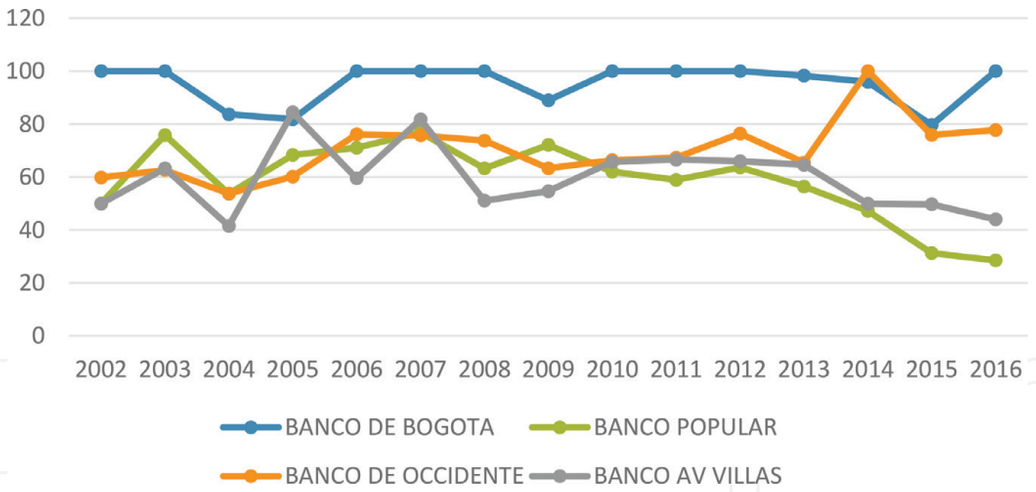

Figure 3.
Efficiency (%) of banks of the grupo aval. Source: self-made.

Figure 4.
Behavior of efficient banks. Source: self-made.

7. Conclusions

The financial sector is important in any economy, since it is the one that brings together those agents that have monetary resources to spare with the agents that need those resources. In Colombia, this sector is one of those that have marked the growth of the economy for several years; even more, at a time of global economic slowdown, it is the one that has definitely had very good profits. An example of this is the year 2016 in which despite the global recession this sector obtained an increase of 24.8% in its profits.

The Colombian banking sector emerges from the crises of the twentieth century, preparing itself to tackle the twenty-first century, through an organization that prioritizes the formation of financial groups of both national and foreign origin; this means that purchases and mergers have been the order of the day. In the last 15 years, the period of time of this investigation, there has been a great movement regarding the number of banks in the sector in each year. Although this period began with 24 banks in 2002, discounting the banks owned by the government and closing 2016 with this same number of banks do not mean that there was no movement in the intervening years.

The Santander Colombia, Scotiabank, HSBC Colombia, Helm, Union Colombiano, Tequendama, Bansuperior, Megabanco, Granahorrar, Colmena, and Conavi banks disappeared from the sector, either because they were purchased or because they merged. The Standard Chartered bank closed voluntarily and the bank Bankboston also settled voluntarily. The following banks entered: Corpbanca, Procredit Colombia, Bancamia, WWB, Coomeva, Finandina, Falabella, Pichincha Coopcentral, Santander de Negocios, Mundo Mujer, Multibank, and Bancompartir.

To study this sector, the DEA methodology is perfectly adjusted since it is not necessary to predetermine the production function and a set of multiple entries and multiple outputs can be worked out to obtain a single indicator per bank and per period studied.

Within this investigation, it has been possible to establish that of the 13 banks that entered the sector during the study period, and that were previously mentioned, 62% have obtained such good results that at least 90% of the years of existence have been efficient and when they are not, the indicator is above 90%.

Overall, it can be determined that the average relative efficiency over the last 15 years of the Colombian banking sector is 86%, despite having raffled the first global financial crisis of this century and living a severe economic recession worldwide.

The highest percentage of efficient banks is in 2014 (71%), for 2016 37% of banks are inefficient.

It was also established that one does not need to be the most important bank, nor the largest one in terms of assets, nor have they obtained the most voluminous profits, nor belong to the most powerful financial group, and nor have years of evolution, to be efficient. Additionally, not being a bank that is part of a very important financial group, it is efficient. Otherwise, so be a robust financial group, this does not mean that as a group, be efficient.

The results also show that there is a large gap between the percentage of efficient and inefficient banks. This gap began in 2006 with 47% points of difference, which increases for 2008 and ends in the last year of the study with more than 50% points.

On the other hand, the foreign banks have been more representative in the total of efficiency than the national banks; this situation only has a very slight change for the year 2016.

8. Recommendations

This research was carried out using public information to which there is free access, but it is evident that for a better approximation to the measurement of relative efficiency it would be very good to have access to information that in Colombia is considered as private. In other words, the directors of the different banks agree to provide the information required to improve this study.

On the other hand, bank managers should take advantage of the conclusions reached to improve their performance, and if that were the case, the performance of the whole group.

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References

[1] BID. Progreso Económico y Social en América Latina. Informe 2005. Buenos Aires: El Ateneo; 2004. 323 p

[2] Parlamento Europeo. A Su Servicio [Internet]. 2017. Available from: http://www.europarl.europa.eu/atyourservice/es/displayFtu.html?ftuId=FTU_4.2.4.html

[3] Superintendencia de Bancos e Instituciones Financieras—SBIF Chile [Internet]. 2017. Available from: http://www.bancafacil.cl/bancafacil/servlet/Contenido?indice=1.2&idPublicacion=3000000000000076&idCategoria=2

[4] Secretaría de Hacienda y Crédito Público. Boletín Estadístico Banca Múltiple. Méjico, D.F.: Comisión Nacional Bancaria y de Valores; 2016. 208 p

[5] Uribe J. Nota Editorial: El sistema financiero colombiano: Estructura y evolución reciente. Revista del Banco de la República. 2013;**LXXXVI**(1023):5-17

[6] Coltefinanciera. Educación Financiera [Internet]. 2017. Available from: http://www.coltefinanciera.com.co/educacion-financiera/sistema-financiero/385-como-esta-estructurado-el-sistema-financiero-en-colombia

[7] SFC. Superintendencia Financiera de Colombia [Internet]. 2017. Available from: https://www.superfinanciera.gov.co/jsp/loader.jsf?lServicio=Publicaciones&lTipo=publicaciones&lFuncion=loadContenidoPublicacion&id=10083710

[8] Secretaría Senado. Leyes Desde 1992, Vigencia Expresa y Control de Constitucional [Internet]. 2017. Available from: http://www.secretariasenado.gov.co/senado/basedoc/estatuto_organico_sistema_financiero.html

[9] Banco de la República. La Historia del Banco [Internet]. 2017. Available from: http://www.banrep.gov.co/sites/default/files/paginas/historia-banco-sept.pdf

[10] Meisel Roca A. El Banco de la República: Antecedentes, Evolución y Estructura. Bogotá: Banco de la República; 1990. 750 p

[11] Arango M. Evolución y Crisis del Sistema Financiero Colombiano, Serie Estudios y Perspectivas. Bogotá: CEPAL; 2006. 101 p

[12] Galán J, Veiga H, Wiper M. Dynamic effects in inefficiency: Evidence from the Colombian banking sector. European Journal of Operational Research. 2015;**240**:562-571

[13] Moncada A, Dopacio C. Information technology: Potential in the Colombian banking sector. In: Soft Comput. in Manag. and Bus. Econ. STUDFUZZ. Vol. 287. 2012. pp. 77-95

[14] Escuela Nacional Sindical. Sector Financiero y Bancario Colombiano. Medellín: Escuela Nacional Sindical; 2015. 222 p

[15] Grupo Aval. Nuestras Compañías [Internet]. 2017. Available from: https://www.grupoaval.com/wps/portal/grupo-aval/aval/nuestras-companias

[16] Grupo Bancolombia. Grupo Bancolombia [Internet]. 2017. Available from: https://www.grupobancolombia.com/wps/portal/acerca-de/informacion-corporativa/quienes-somos/

[17] Grupo Sura. Grupo Sura [Internet]. 2017. Available from: https://www.gruposura.com/Inversiones/grupo-bancolombia/Paginas/default.aspx

[18] Davivienda. Banco Davivienda [Internet]. 2017. Available from: https://www.davivienda.com/wps/portal/inversionistasespanol/

inversionistas/AcercaBanco/quienes_somos/davivienda/!ut/p/b1/04_SjzQzszCysDAzMdWP0I_KSyzLTE8sycz PS8wB8aPM4sNMDQK9vN 0NDfw9PdwMPF18QkzMAwONv EMMgQoigQoMcABHA0L6w_ Wj8CpxNYAqwGOFn0d-bqp-blSOpaeuoyIAOw

[19] Banco Davivienda. Informe de Gestión 2016. Bogotá: Davivienda; 2017. 141 p

[20] Colpatria. Colpatria Multibanca [Internet]. 2017. Available from: https://www.colpatria.com/Acerca-de/banco-colpatria/informacion-institucional/nuestra-organizacion

[21] BBVA. Banco Bilbao Vizcaya Argentaria Colombia [Internet]. 2017. Available from: https://www.bbva.com.co/meta/historia/

[22] Citibank. Citi España [Internet]. 2017. Available from: http://www.citibank.com/spain/citi/historia.htm

[23] Citibank Colombia. Citi [Internet]. 2017. Available from: https://www.citibank.com.co/Citivalores/quienes_somos/index.htm

[24] Citigroup. Citi Institucional [Internet]. 2017. Available from: https://www.citibank.com.co/institucional/historia.htm#

[25] Banco GNB Sudameris. Banco GNB Sudameris [Internet]. 2017. Available from: https://www.gnbsudameris.com.co/quienes-somos

[26] Corpbanca. Presentación Institucional. Bogotá: Corpbanca; 2015. 25 p

[27] Asobancaria. Informe de Tipificación la Banca Colombiana en 2016. Bogotá: Asobancaria; 2017. 146 p

[28] Yang M, Li Y, Chen Y, Liang L. An equilibrium efficiency frontier data envelopment analysis approach for evaluating decision-making units with fixed-sum outputs. European Journal of Operational Research. 2014;**239**(2):479-489

[29] Wei Q, Yang H. A data envelopment analysis (DEA) evaluation method based on sample decision making units. International Journal of Information Technology and Decision Making. 2010;**9**(4):601-624

[30] Dotoi M, Epicoco N, Falagario M, Sciancalepore F. A cross-efficiency fuzzy data envelopment analysis technique for performance evaluation of decision making units under uncertainty. Computers & Industrial Engineering. 2015;**79**:103-114

[31] Rodríguez G. Indicadores DEA (Data Envelopment Analysis) de eficiencia y productividad para las actividades de extensión universitaria. Aplicación en la Universidad Nacional de Colombia. Bogotá: Centro Editorial Facultad de Ciencias Económicas Universidad Nacional de Colombia; 2011, 2011. 262 p

[32] Iyer K, Banerjee P. Measuring and benchmarking managerial efficiency of project execution schedule performance. International Journal of Project Management. 2016;**34**(2):219-236

[33] Ghasemi M, Ignatius J, Lozano S, Emrouznejad A, Hatami-Marbini A. A fuzzy expected value approach under generalized data envelopment analysis. Knowledge-Based Systems. 2015;**89**:148-159

[34] Lau K. Measuring distribution efficiency of a retail network through data envelopment analysis. International Journal of Production Economics. 2013;**146**(2):598-611

[35] Charnes A, Cooper W. Programming with linear fractional

functional. Naval Research Logistics Quarterly. 1962;**9**:67-88

[36] Mahdiloo M, Tavana M, Saen R, Noorizadeh A. A game theoretic approach to mideling undesirable outputs and efficiency decomposition in data envelopment analysis. Applied Mathematics and Computation. 2014;**244**:479-492

[37] Puri J, Yadav S. A concept of fuzzy imput mix-efficiency in fuzzy DEA and its application. Expert Systems with Applications. 2013;**40**(5):1437-1450

[38] Puri J, Yadav S. A fuzzy DEA model with undesirable fuzzy outputs and its application to the banking sector in India. Expert Systems with Applications. 2014;**41**(14):6419-6432

[39] Svitálková Z. Comparision and evaluation of Bank efficiency in selected countries in EU. Procedia Economics and Finance. 2014;**12**:644-653

[40] Samuel G, Hongzhong Z, Thierry B. Technical efficiency assessment using data envelopment analysis: An application to the banking sector of Côte d'Ivoire. Procedia-Social and Behavioral Sciences. 2016;**235**:198-207

[41] Ghahraman A, Prior D. A learning ladder to ward efficiency: Proposing network-based stepwise benchmark selection. Omega. 2016;**63**:83-93

[42] Johnes J, Izzeldin M, Pappas V. A comparison of performance of Islamic and conventional banks. Journal of Economic Behavior and Organization. 2014;**103**:93-107

[43] Zhou Z, Sun L, Yang W, Liu W, Ma C, Bargaining Game A. Model for efficiency decomposition in the centralized model. Computers & Industrial Engineering. 2013;**4**(1):103-108

[44] Liu J, Lu W, Kweh Q, Wang C. Exploring the benchmarks of the Taiwanese investment trust corporations: Management and investment efficiency perspectives. European Journal of Operational Research. 2016;**248**:607-618

[45] Aghayi N, Maleki B. Efficiency measurement of DMUs with undesirable outputs under uncertainty based on the directional distance function: Application on bank industry. Energy. 2016;**112**:376-387

[46] Herrera-Restrepo O, Triantis K, Seaver W, Paradi J. Bank branch operational performance: A robus tmultivariate and clustering approach. Expert Systems with Applications. 2016;**50**:107-119

[47] Okuda H, Aiba D. Determinants of operational efficiency and total factor productivity change of major Cambodian financial institutions: A data envelopment analysis during 2006-13. Emerging Markets Finance and Trade. 2016;**52**:1455-1471

[48] Juo J, Fu T, Yu M, Lin Y. Non-radial profit performance: An application to Taiwanese banks. Omega. 2016;**65**:111-121

[49] Rahman M, Lambkin M, Hussain D. Value creation and appropriation following M & A: A data envelopment analysis. Journal of Business Research. 2016;**69**:5628-5635

[50] Sarmiento M, Cepeda A, Mutis H, Pérez J. Nueva evidencia sobre la eficiencia de la Banca Colombiana: Una medición con modelos de frontera no-paramétricos. Archivos de Economía. 2014;**392**:1-49

[51] Piraquete J, Piñeros J, Mondragón L. Eficiencia de los establecimientos bancarios (EB): una aproximación

mediante modelos DEA. Borradores de Economía. 2013;**798**:1-39

[52] Rodríguez-Lozano G, Sarmiento-Muñoz M. La eficiencia relativa del sector real vs. la del sector financiero de la economía colombiana. Apuntes del CENES. 2017;**36**(64):113-140

[53] Podinovski V, Bouzdine-Chameeva T. Consistent weight restrictions in data envelopment analysis. European Journal of Operational Research. 2015;**244**:201-209

[54] Charnes A, Cooper W, Golany B, Seiford L, Stutz J. Foundations of data envelopment analysis and Pareto-Koopmans empirical production functions. Journal of Econometrics. 1985;**30**:91-107

[55] Banker R, Charnes A, Cooper W. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science. 1984;**30**(9):1078-1092

[56] Paradi J, Rouatt S, Zhu H. Two-stage evaluation of bank branch efficiency using data envelopment analysis. Omega. 2011;**39**:99-109

[57] Rodríguez-Lozano G. Indicadores de eficiencia DEA (data envelopment analysis) para las sociedades corredoras de seguros en el medio financiero colombiano. In: Facultad vde Ciencias Económicas Universidad Nacional de Colombia, editor. La administración en el siglo XXI: Herencia e innovación en conceptos y herramientas para las ciencias de gestión. EditorialUN; 2016. pp. 173-183

[58] Rodríguez-Lozano G. Medición de la eficiencia relativa a en dos subsectores de la economía colombiana desde 1993 a 2002 utilizando Data Envelopment Analysis (DEA). INNOVAR. Revista de Ciencias Administrativas y Sociales. 2003;**22**:121-144

[59] Rodríguez-Lozano G. Medición de la eficiencia relativa en tres subsectores de la economía colombiana desde 1993 a 1999 utilizando Data Envelopment Analysis (DEA). INNOVAR. Revista de Ciencias Administrativas y Sociales. 2003;**21**:145-181

[60] Feng G, Wang C. Why European banks are less profitable than U.S. banks: A decomposition approach. Journal of Banking & Finance. 2018;**90**:1-16

[61] Andi. Colombia: Balance 2015 y Perspectivas 2016. Bogotá; 2016. 77 p

[62] Asobancaria. La Banca Colombiana en 2015. Bogotá: Asobancaria; 2016. 146 p